CLAIMS

[1] A solid oxide fuel cell comprising at least an electrolyte, an air electrode, and a fuel electrode, wherein

the air electrode comprises a perovskite oxide containing at least manganese, and

the content of manganese in the surface of a layer which is in contact with the fuel electrode is 0.3 to 4% by weight, where the surface is on the fuel electrode side of the layer.

[2] The solid oxide fuel cell according to claim 1, wherein the layer in contact with the fuel electrode is the electrolyte.

[3] The solid oxide fuel cell according to claim 1, wherein

a porous layer is provided between the fuel electrode and the electrolyte,

the layer in contact with the fuel electrode is the porous layer,

the porous layer is formed of a zirconia-containing fluorite oxide, has a thickness of 5 to 40 μm, and a porosity larger than the electrolyte.

[4] The solid oxide fuel cell according to any one of claims 1 to 3, wherein an air-side electrode reaction layer is provided between the air electrode and the electrolyte.

[5] The solid oxide fuel cell according to any one of claims 1 to 4, wherein the content of manganese in the electrolyte in its surface on the air electrode side is larger than the content of the manganese component in the electrolyte in its surface on the fuel electrode side.

[6] The solid oxide fuel cell according to any one of claims 1 to 5, wherein the content of manganese in the electrolyte in its surface on the fuel electrode side is 0.6 to 3.5% by weight.

[7] The solid oxide fuel cell according to any one of claims 1 to 6, wherein the content of manganese in the electrolyte in its surface on the fuel electrode side is 0.9 to 3% by weight.

[8] The solid oxide fuel cell according to any one of claims 1 to 7, wherein the content of manganese in the electrolyte in its surface on the air electrode side is less than 10% by weight.

[9] The solid oxide fuel cell according to any one of claims 1 to

7, wherein the content of manganese in the electrolyte in its surface on the air electrode side is less than 6% by weight.

[10] The solid oxide fuel cell according to any one of claims 4 to 9, wherein the air-side electrode reaction layer comprises a mixed electrically conductive ceramic which comprises a manganese- and nickel-containing perovskite oxide and a zirconia-containing oxide and the air-side electrode reaction layer has interconnected open pores.

[11] The solid oxide fuel cell according to any one of claims 4 to 9, wherein the air-side electrode reaction layer comprises a mixed electrically conductive ceramic which comprises a manganese- and nickel-containing perovskite oxide and cerium oxide and the air-side electrode reaction layer has interconnected open pores.

[12] The solid oxide fuel cell according to any one of claims 4 to 9, wherein the air-side electrode reaction layer comprises a mixed electrically conductive ceramic which comprises a manganese- and nickel-containing perovskite oxide and a lanthanum- and gallium-containing perovskite oxide and the air-side electrode reaction layer has interconnected open pores.

[13] The solid oxide fuel cell according to any one of claims 10 to 12, wherein the content of the manganese- and nickel-containing perovskite oxide in the air-side electrode reaction layer is 30 to 70% by weight.

[14] The solid oxide fuel cell according to any one of claims 10 to 13, wherein the manganese- and nickel-containing perovskite oxide is represented by $(Ln_{1-x}A_x)_y(Mn_{1-z}Ni_z)O_3$ wherein Ln represents one or at least two elements selected from the group consisting of Sc, Y, La, Ce, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, and Lu; A represents Ca or Sr; x satisfies $0.15 \leq x \leq 0.3$; y satisfies $0.97 \leq y \leq 1$; and z satisfies $0.02 \leq z \leq 0.10$.

[15] The solid oxide fuel cell according to claim 10, 13, or 14, wherein the zirconia-containing oxide is zirconia containing scandia in solid solution.

[16] The solid oxide fuel cell according to claim 10, 13, or 14, wherein the zirconia-containing oxide is zirconia containing scandia and yttria in solid solution.

[17] The solid oxide fuel cell according to claim 11, 13, or 14,

wherein the cerium oxide is represented by $(CeO_2)_{1-2X1}(J_2O_3)_{X1}$ wherein J represents Sm, Gd, or Y; and X1 satisfies $0.05 \leq X1 \leq 0.15$.

[18] The solid oxide fuel cell according to any one of claims 4 to 15, wherein the air-side electrode reaction layer comprises at least two layers of a first layer on the air electrode side and a second layer on the electrolyte side.

[19] The solid oxide fuel cell according to claim 18, wherein

the first layer comprises a mixture of a manganese-containing perovskite oxide with zirconia containing scandia and/or yttria in solid solution and has interconnected open pores, and

the second layer comprises zirconia containing scandia in solid solution and has a porosity larger than the electrolyte.

[20] The solid oxide fuel cell according to claim 18, wherein

the first layer comprises a mixture of a manganese-containing perovskite oxide with cerium containing oxide and has interconnected open pores, and

the second layer comprises zirconia containing scandia in solid solution and has a porosity larger than the electrolyte.

[21] The solid oxide fuel cell according to claim 18, wherein

the first layer comprises a mixture of a manganese-containing perovskite oxide with a lanthanum- and gallium-containing perovskite oxide and has interconnected open pores, and

the second layer comprises zirconia containing scandia in solid solution and has a porosity larger than the electrolyte.

[22] The solid oxide fuel cell according to claim 18, wherein

the first layer comprises a lanthanum- and cobalt-containing perovskite oxide and has interconnected open pores, and

the second layer comprises zirconia containing scandia in solid solution and has a porosity larger than the electrolyte.

[23] The solid oxide fuel cell according to claim 18, wherein

the first layer comprises a mixture of a manganese-containing perovskite oxide with zirconia containing scandia and/or yttria in solid solution and has interconnected open pores, and

the second layer comprises cerium oxide and has a porosity larger than the electrolyte.

[24] The solid oxide fuel cell according to any one of claims 18

to 23, wherein the diameter of pores in the second layer is 0.1 to 10 μm.

[25] The solid oxide fuel cell according to any one of claims 18 to 24, which satisfies a relationship represented by formula d1 > d2 > d3 wherein d1 represents the diameter of pores in the air electrode; d2 represents the diameter of pores in the first layer; and d3 represents the diameter of pores in the second layer.

[26] The solid oxide fuel cell according to any one of claims 18 to 25, wherein the second layer has a porosity of 3 to 40%.

[27] The solid oxide fuel cell according to any one of claims 18 to 24, which satisfies a relationship represented by formula $a1 \geq a2 \geq a3 > a4$ wherein a1 represents the porosity of the air electrode; a2 represents the porosity of the first layer; a3 represents the porosity of the second layer; and a4 represents the porosity of the electrolyte.

[28] The solid oxide fuel cell according to any one of claims 18 to 24, wherein the second layer has a thickness of 5 to 50 μm.

[29] The solid oxide fuel cell according to any one of claims 18 to 24, wherein the first layer has a thickness of 5 to 50 μm.

[30] The solid oxide fuel cell according to any one of claims 23 to 29, wherein the cerium oxide constituting the second layer is represented by $(CeO_2)_{1-2X1}(J_2O_3)_{X1}$ wherein J represents Sm, Gd, or Y; and X1 satisfies $0.05 \leq X1 \leq 0.15$.

[31] The solid oxide fuel cell according to any one of claims 20, 21, and 23 to 30, wherein the manganese-containing perovskite oxide constituting the first layer is a lanthanum manganite represented by $(La_{1-x}A_x)_yMnO_3$ wherein A represents Ca or Sr; x satisfies $0.15 \leq x \leq 0.3$; and y satisfies $0.97 \leq y \leq 1$.

[32] The solid oxide fuel cell according to any one of claims 20, 21, and 23 to 30, wherein the manganese-containing perovskite oxide constituting the first layer is a lanthanum manganite represented by $(La_{1-x}A_x)_y(Mn_{1-z}Ni_z)O_3$ wherein A represents Ca or Sr; x satisfies $0.15 \leq x \leq 0.3$; y satisfies $0.97 \leq y \leq 1$; and z satisfies $0.02 \leq z \leq 0.10$.

[33] The solid oxide fuel cell according to any one of claims 20 and 24 to 32, wherein the cerium oxide constituting the first layer is represented by $(CeO_2)_{1-2X1}(J_2O_3)_{X1}$ wherein J represents Sm, Gd, or Y; and X1 satisfies $0.05 \leq X1 \leq 0.15$.

[34] The solid oxide fuel cell according to any one of claims 1 to

33, wherein the electrolyte comprises a layer formed of zirconia containing scandia and/or yttria in solid solution.

[35] The solid oxide fuel cell according to any one of claims 1 to 34, wherein the electrolyte comprises at least two layers of a layer which is provided on the air-side electrode reaction layer side and comprises zirconia containing yttria in solid solution and a layer which is provided on the fuel electrode side and comprises zirconia containing scandia in solid solution.

[36] The solid oxide fuel cell according to any one of claims 1 to 34, wherein the electrolyte comprises at least two layers of a layer which is provided on the air-side electrode reaction layer side and comprises zirconia containing scandia in solid solution and a layer which is provided on the fuel electrode side and comprises zirconia containing yttria in solid solution.

[37] The solid oxide fuel cell according to any one of claims 1 to 34, wherein the electrolyte comprises at least three layers of a layer which comprises zirconia containing scandia in solid solution, a layer which comprises zirconia containing yttria in solid solution, and a layer which comprises zirconia containing scandia in solid solution stacked in that order.

[38] The solid oxide fuel cell according to any one of claims 1 to 37, wherein the air electrode is formed of a lanthanum manganite represented by $(La_{1-x}A_x)_yMnO_3$ wherein A represents Ca or Sr; x satisfies $0.15 \leq x \leq 0.3$; and y satisfies $0.97 \leq y \leq 1$.

[39] The solid oxide fuel cell according to any one of claims 3 to 38, wherein the content of manganese in the electrolyte in its surface on the air electrode side is larger than the content of manganese in the porous layer, formed of a fluorite oxide, in its surface on the fuel electrode side.

[40] The solid oxide fuel cell according to claim 39, wherein the content of the manganese component in the porous layer, formed of a fluorite oxide, in its surface on the fuel electrode side is 0.6 to 3.5% by weight.

[41] The solid oxide fuel cell according to claim 39, wherein the content of the manganese component in the porous layer, formed of a fluorite oxide, in its surface on the fuel electrode side is 0.9 to 3% by

weight.

[42] The solid oxide fuel cell according to any one of claims 3 to 41, wherein the porous layer formed of fluorite oxide has a porosity of 3 to 30%.

[43] The solid oxide fuel cell according to any one of claims 3 to 42, which satisfies a relationship represented by formula $a1 < a2 < a3$ wherein a1 represents the porosity of the electrolyte; a2 represents the porosity of the porous layer formed of the fluorite oxide; and a3 represents the porosity of the fuel electrode.

[44] The solid oxide fuel cell according to any one of claims 3 to 43, wherein the diameter of pores in the porous layer formed of the fluorite oxide is 0.05 to 2 μm.

[45] The solid oxide fuel cell according to any one of claims 3 to 44, wherein the fluorite oxide is zirconia containing scandia in solid solution.

[46] The solid oxide fuel cell according to any one of claims 3 to 44, wherein the fluorite oxide is zirconia containing scandia and yttria in solid solution.

[47] The solid oxide fuel cell according to claim 2, wherein the electrolyte in its film surface on the fuel electrode side has such a crystal grain size distribution that the 3% diameter of the crystal grains is not less than 3 μm and the 97% diameter of the crystal grains is not more than 20 μm.